



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

Langley

DEC 12 1974

REPLY TO
ATTN OF: GP

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No.

: 3,849,877

Government or
Corporate Employee

: Ampex Corp.
Redwood City, CA

Supplementary Corporate
Source (if applicable)

: ~~~~~

NASA Patent Case No.

: LAR-10,994-1

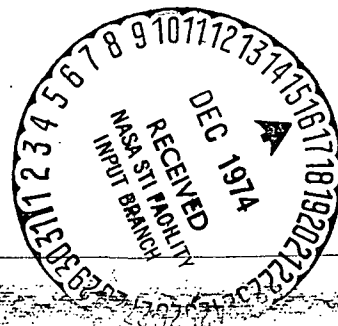
NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES ☒ NO ☐

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

Bonnie L. Woerner

Bonnie L. Woerner
Enclosure



(NASA-Case-LAR-10994-1) METHOD FOR MAKING
CONDUCTORS FOR FERRITE MEMORY ARRAYS
Patent (NASA) 6 p CSCL 11D

N75-13032

00/24 03979 Unclas

[54] **METHOD FOR MAKING CONDUCTORS FOR FERRITE MEMORY ARRAYS**

[76] Inventors: **James C. Fletcher**, Administrator of the National Aeronautics and Space Administration with respect to an invention of; **Clarence H. Heckler, Jr.**, Palo Alto; **Paul D. Baba**, San Carlos; **Nutan C. Bhiwandker**, Mt. View, all of Calif.

[22] Filed: **Aug. 22, 1973**

[21] Appl. No.: **390,466**

[52] U.S. Cl. **29/604, 29/420, 75/200, 340/174 MA**

[51] Int. Cl. **H01f 7/06**

[58] Field of Search **29/604, 420, 625, 624; 340/174 MA, 174 JA; 252/514, 512, 513; 75/200**

[56] **References Cited**

UNITED STATES PATENTS

3,040,301	6/1962	Howatt et al.	29/604 U X
3,075,280	1/1963	Jack et al.	29/625
3,123,748	3/1964	Brownlow	29/604 U X
3,144,330	8/1964	Storchheim	29/420 U X

3,414,641	12/1968	Miller	252/514 X
3,450,918	6/1969	Burr	29/598 X
3,534,471	10/1970	Babbitt et al.	29/604

Primary Examiner—C. W. Lanham

Assistant Examiner—Carl E. Hall

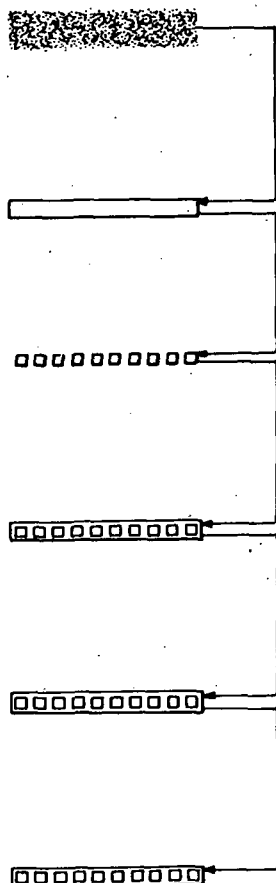
Attorney, Agent, or Firm—Wallace J. Nelson; Howard J. Osborn; John R. Manning

[57] **ABSTRACT**

Method of forming ferrite memory arrays. The ferrite memory arrays are made from pre-formed metal conductors for the ferrite arrays. The conductors are made by forming a thin sheet of a metallizing paste of metal alloy powder, drying the paste layer, bisque firing the dried sheet at a first temperature and then punching the conductors from the fired sheet. During the bisque firing, the conductor sheet shrinks to 58 percent of its pre-fired volume and the alloy particles sinter together.

The conductors formed are embedded in ferrite sheet material and finally fired at a second higher temperature during which firing the conductors shrink approximately the same degree as the ferrite material.

10 Claims, 1 Drawing Figure



PREPARE A LAYER OF POWDERED CONDUCTIVE METAL WITH AN ORGANIC BINDER TO FORM A PASTE

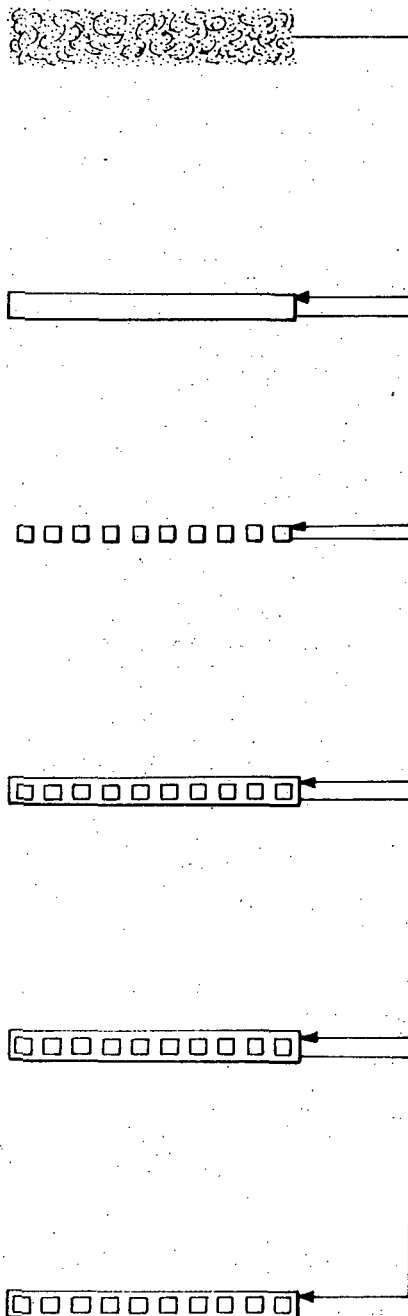
DRY AND BISQUE FIRE PASTE LAYER 20-60 MINUTES AT 800°-900° C TO FORM A CONDUCTOR SHEET

FORM A PLURALITY OF INDIVIDUAL CONDUCTORS FROM THE BISQUE FIRED SHEET

EMBED THE INDIVIDUAL CONDUCTORS IN A PREFORMED FERRITE SHEET

FIRE THE EMBEDDED FERRITE SHEET AT 1340°-1360° C FOR 1-20 HOURS IN AN OXYGEN ATMOSPHERE AND COOL IN NITROGEN

RECOVER A FERRITE MEMORY ARRAY



PREPARE A LAYER OF POWDERED CONDUCTIVE METAL WITH AN ORGANIC BINDER TO FORM A PASTE

DRY AND BISQUE FIRE PASTE LAYER 20-60 MINUTES AT 800°-900° C TO FORM A CONDUCTOR SHEET

FORM A PLURALITY OF INDIVIDUAL CONDUCTORS FROM THE BISQUE FIRED SHEET

EMBED THE INDIVIDUAL CONDUCTORS IN A PREFORMED FERRITE SHEET

FIRE THE EMBEDDED FERRITE SHEET AT 1340°-1360° C FOR 1-20 HOURS IN AN OXYGEN ATMOSPHERE AND COOL IN NITROGEN

RECOVER A FERRITE MEMORY ARRAY

METHOD FOR MAKING CONDUCTORS FOR FERRITE MEMORY ARRAYS

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the making of ferrite memory arrays and more particularly to a method of forming and embedding metal conductors in the ferrite material. The method of the invention results in the controlled shrinkage of the conductors eliminating breakage of the conductors and ferrite materials during final firing of the ferrite materials by eliminating the strains normally built up between the ferrite and the conductors during the final firing of the ferrite.

2. Prior Art

In the past, ferrite memory arrays in which metal conductors were embedded in blocks of ferrite were formulated by embedding a paste of metal particles, binder, and a solvent in the ferrite material and firing the ferrite material in the form of sheets at temperatures on the order of 1,000° to 1,350°C for 2 to 24 hours. During the firing of the ferrite, the solvent of the conductor paste volatilized along with the binder and the precious metal particles were sintered together. Because of the shrinkage due to the volatilization of the binder and solvent, and the sintering, the conductor normally shrunk considerably more than the ferrite material in which it was embedded. To match the shrinkage the particle size and shape and the material-to-binder ratio had to be closely controlled. Even so, strains and frictional forces between the ferrite and conductor materials developed which very often resulted in breakage of the conductor material which had previously not attained any significant strength. Because of these problems, an inordinately high proportion of the fired ferrite arrays were rendered useless.

SUMMARY OF THE INVENTION

The present invention substantially reduces the rate of failure in the final firing of ferrite arrays by providing a method wherein the conductors for the arrays are pre-formed and bisque fired at temperatures significantly lower than the temperature of the final firing of the ferrite array. This causes the metal particles comprising the conductor to sinter together to pre-form the conductor and allow it to obtain initial structural strength. The sintering and driving off of the solvent and volatilizable organic binder significantly pre-shrinks the formed conductor material so that during the final firing of the ferrite material, the shrinkage of the embedded conductor material will approximate the shrinkage of the ferrite.

According to the present invention a paste containing the metal particles suspended in a vehicle of organic binder and a solvent is formed into a layer approximately 5 to 15 mls. thick, preferably 8 to 10 mls., by doctor-blading and then drying for approximately 16 hours at 30° to 40°C. or until the conductor material paste is thoroughly dried. The thickness of the dried sheet of conductor material will, of course, depend on

the original thickness of the conductor material paste. In general, the thickness of the dried conductor material layer formed from the previously described wet conductor material paste layer will be on the order of 1 to 4 mls. In a preferred embodiment, the dried sheets of conductor material will range in thickness from 2.4 to 3.2 mls. The dried conductor material sheet is then placed between two spaced alumina setter sheets approximately 6 to 10 mls. apart, preferably 6 to 7 mls., and bisque fired at about 800° to 900°C., preferably 840° to 855°C., for about 20 to 60 minutes. The temperature range and time of firing depends on the composition of the particular alloy used as the conductor material. The firing takes place in an oxidizing atmosphere which is usually air or oxygen. Preferably the firing is carried out for 45 minutes in an oxygen atmosphere.

During the bisque firing, the particles in the conductor material sheet sinter together to form a metallic conductor sheet of about 58 percent of its prefired volume and from 1 to 3 mls. thick, preferably 2 to 2.3 mls., depending upon the particular alloy composition forming the conductor material. Individual conductors are then punched from the thus formed sheet by means of a die set. Conductors formed are by way of example about 4 inches \times 0.0055 inch \times 0.0025 inch although any dimensional range desired may be utilized. Typical examples are from 4.1 to 4.3 inches long, from 5 to 6 mls. wide, and from 2 to 2.3 mls. thick. The conductors are then embedded in pre-formed ferrite sheets and the assembly fired at about 1,000° to 1,375°C. depending upon the particular ferrite material composition. Structures using the preferred embodiments of the invention are usually fired at temperatures in the range of 1,340° to 1,360°C., with 1,350°C. being preferred. Firing time varies from 1 to 20 hours depending upon the ferrite compositions, with 4 to 5 hours being utilized with the preferred embodiments. It has been found that the shrinkage of the bisque fired conductor material and ferrite closely approximate each other, the linear shrinkage being generally on the order of 20 percent during the final firing step.

The metallizing paste used in the formulation of the conductors generally comprises from about 60 to 95 percent preferably 75 to 90 percent of metal powder and from 5 to 40 percent preferably 10 to 25 percent of an organic binder powder with sufficient amount of an inert organic vehicle to form a spreadable paste. It is generally preferred to use a conductor material composition where platinum comprises the highest proportion of metal powder. An example of a suitable metallizing composition is one sold by duPont de Nemours Co. under the designation DP8283 comprising 60 percent by weight of an alloy of platinum, palladium and gold in a ratio of 50:25:25, an organic resin binder and organic solvent, the overall solids content being 80 percent by weight.

Generally suitable metallizing conductor materials are formed of metals selected from the group consisting of gold, platinum, palladium, rhodium, iridium or other metals of good conductivity and low reactivity with ferrites. The conductor material is fabricated so that the alloy has a melting temperature higher than the final firing temperature at which sintering takes place, and a linear shrinkage equal to or no greater than 5 percent more than the linear shrinkage of the ferrite material in which the conductors are to be embedded.

DESCRIPTION OF PREFERRED EMBODIMENTS

A sheet of conductor material is formed by doctor-blading a conductor material paste of metal particles comprised of an alloy of gold, platinum and palladium and supplied by E. I. duPont under the identification platinum alloy paste DP8283 as mentioned above. The doctor blade utilized has a height of approximately 10 mls. The sheets are dried for approximately 16 hours at 30° to 40°C and thereafter have a thickness of approximately 3 to 3.2 mls. The conductor sheet is then bisque fired for approximately 45 minutes at 840°C. after being placed between two flat alumina setter sheets spaced 6 to 7 mls. apart. During the bisque firing, the organic binder volatilizes and the alloy powder sinters together to form a metallic conductor sheet approximately 2.5 mls. thick and having a volume of approximately 58 percent of its pre-fired volume. Conductors are formed from the bisque fired sintered sheet utilizing a punch and die set and are approximately 4 inches × 0.0055 inch × 0.0025 inch.

Ferrite sheets are prepared by milling a ferrite composition of $Mg_{.864} Mn_{.432} Zn_{.114} Fe_{.728} O_4$ with a polyvinyl chloride binder on a calendar mill with 3 inches rollers and with roller speed ratios of 1:1 and 1.4:1, maintained at a temperature of 80°C. for 40 minutes. A coarsesurfaced sheet resulted. This was transformed into 7 mil sheets by cutting 1 inch × 3 inches pieces from the calendered sheet and thermopressing the pieces to the desired thickness on a Carver hydraulic press at a platen temperature of 150°C., using shims to limit the closing of the platens.

The ferrite sheets are then embossed with channels for embedding the conductors. The lamina are embedded by thermopressing with an embossing mold using a pressure of 5,000 lbs. at 60°C. using a shim type of embossing mold. The channels were either 0.003 or 0.006 inch wide.

After laminae are embossed, they are coated with a squeegee medium, L. Reusche and Co. Type 163C, scraped, and dried. Since this medium is over 90 percent pine oil, only a thin layer of resin is deposited in the bottom of the channels when the laminae are dried. This is used to cement the conductors in the channels during assembly.

The conductors are embedded in the embossed ferrite lamina and secured in place by thermobonding at a temperature of 60°C. under light pressure. The laminae are then thermopressed between shims to embed the conductors so that they are flush with the surface of the lamina.

The assembly of the laminae to form monolithic arrays was accomplished with the aid of a multisection assembly jig and a pair of trimming dies. After the embedding of a full complement of conductors in a word lamina and in a digit/sense lamina was completed, each lamina was trimmed to a size that would expose 0.050 inch at each end of the conductors. This was accomplished by making the digit/sense lamina 0.10 inch longer than the word lamina, the word lamina 0.10 inch wider than the digit/sense lamina, and the 0.0008 inch insulating lamina 0.1 inch less than the maximum length and width. The overall array dimensions were 4.159 inches × 1.160 inches before firing.

Bonding of the laminae is accomplished by applying a pressure of 8 pounds per square inch at a temperature

of 160°C. to the assembled and aligned laminae for 1 hour.

Each array is placed on an alumina setter sheet covered with a coating of thoria powder to prevent sticking. A second alumina setter is supported over the top of the array by a pair of spacers. The arrays are fired in a tube furnace at 1,350°C. for 4 hours in an oxygen atmosphere and then cooled in nitrogen.

During the final firing, the conductors shrink approximately 20 percent which approximates the shrinkage of the ferrite, thus substantially eliminating any strains between the ferrite and the conductor material and thereby greatly reducing instances of broken conductors due to frictional forces between the ferrite and the conductor material.

While the invention has been explained by a detailed description of certain specific embodiments, it is understood that various modifications and substitutions can be made in any of them within the scope of the appended claims which are intended to also include equivalents of such embodiments.

I claim:

1. A method of forming a ferrite memory array comprising forming a layer of a metal conductor material paste composition comprising from 60 to 95 percent by weight of a powdered metal having good conductivity and a low reactivity with ferrites, and from 5 to 40 percent by weight of an organic binder together with an organic vehicle, drying said layer, bisque firing said dried layer at a first temperature below the melting point of said metal, thereby reducing the density of the conductor layer to a first degree by sintering said powdered metal together to form a conductor sheet, forming a plurality of individual conductors from the bisque fired sheet, embedding said conductors in a ferrite sheet and then firing said ferrite sheet at a second and higher temperature than said first temperature to further shrink the conductor material at a rate compatible with the ferrite shrinkage.

2. A method as claimed in claim 1 wherein said powdered metal is selected from the group consisting of gold, platinum, palladium, rhodium, iridium and mixtures and alloys thereof.

3. A method as claimed in claim 1 wherein said powdered metal is selected from the group consisting of gold, platinum, palladium and mixtures and alloys thereof.

4. A method as claimed in claim 3 wherein said metal comprises about 80 percent by weight of said conductor material paste composition.

5. A method as claimed in claim 1 wherein said first temperature ranges from about 800° to about 900°C.

6. A method as claimed in claim 5 wherein said second temperature ranges from approximately 1,000°C to approximately 1,375°C for 1 to 20 hours.

7. A method as claimed in claim 2 wherein said first temperature ranges from about 840° to 855°C, said bisque firing being carried out for 20 to 60 minutes and wherein said second and higher temperature ranges from 1,340° to 1,360°C and said firing is from 1 to 20 hours.

8. A method as claimed in claim 2 wherein said bisque firing is carried out at a temperature of about 840° to 850°C for about 20 to 60 minutes and said firing is carried out at a temperature of about 1,340° to 1,360°C for 4 to 5 hours.

5

9. A method as claimed in claim 3 wherein said bisque firing is carried out at a temperature of about 840° to 850°C for about 20 to 60 minutes and said firing is carried out at a temperature of about 1,340° to 1,360°C for 4 to 5 hours.

6

10. A method as claimed in claim 3 wherein said sheet of metal paste is initially from 5 to 15 mils thick and from 1 to 4 mils thick after drying.

* * * * *

5

10

15

20

25

30

35

40

45

50

55

60

65